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A LABORATORY METHOD FOR REARING AND PARASITIZING THE
CALIFORNIA RED SCALE FOR TOXICOLOGICAL STUDIES

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A convenient method for rearing and parasitizing the California red scale (Aonidiella aurantii (Mask.)) was developed by the writers while conducting studies on the effect of various insecticidal treatments on the scale and its parasites, Habrolepis rouri Comp. and Comperiella bifasciata How.

A technique for rearing the California red scale for both biological and toxicological studies was developed by Munger ^{2/} and adapted to the fumigation technique by Yust and Munger. ^{3/} Their method consists of propagating scales on lemons placed on bottles filled with tap water in which the stems are submerged. The young scales transfer from a heavily infested "reservoir" lemon to a fresh fruit by crawling on a paper frustum of a cone fastened between the two lemons. The frustum is attached to the reservoir lemon by hard paraffin wax, and the fresh lemon is placed on top of the frustum with the stem inserted in a small vial of tap water. The reservoir lemons are placed in a "shade" consisting of a wooden frame covered with brown wrapping paper, the lower half of which is painted black. The crawlers move upward and toward the light to the fresh fruit, where they settle. Settling of crawlers on the uppermost portion of the reservoir lemon is not desirable and is prevented by coating the stylar end with paraffin. When selecting lemons from the field, green,

^{1/} The writers are indebted to Francis Munger, Division of Fruit Insect Investigations, for many helpful suggestions.

^{2/} Munger, F. A method for infesting lemon fruit with red scale. U. S. Bur. Ent. and Plant Quar. ET-120, 3 pp., illus. 1938. (Processed)

^{3/} Yust, H. R., and Munger, F. California red scale. Laboratory procedure in studies on chemical control of insects. Symposium of Entomology. (Unpublished manuscript,)

turgid fruits are preferable. Before the fruits are infested they are submerged in a 3-percent solution of warm sodium tetraborate (borax) to eliminate rot and mold infection of the fruit.

For the rearing of scales the above method proved to be entirely satisfactory. Because the present study also includes the effect of toxicological treatment on immature stages of various parasites, however, a method was desired that was more adaptable to the rearing of the parasite as well as the host. As in the previous method, the lemons had to be supplied with moisture to keep them in a turgid condition. It was not convenient to keep them on bottles since the type of cage used for obtaining uniform parasitization of the scales would not accommodate both the bottle and the lemon. It was also desirable to have a method that would require little attention after the infestations had been made, especially during the period after the stems had fallen off the lemons, and the water level in the bottle had to be raised at frequent intervals to keep it in contact with the base of the lemon. This was particularly true under conditions of low relative humidity.

In the present method the lemons are selected, treated and infested in the manner described by Yust and Munger (loc. cit.). After infestation, the stem is pulled out and the lemon is fastened with hot paraffin to the upper surface of a metal bottle cap at four points, with the stem end protruding through a $1\frac{1}{2}$ -inch hole punched in the cap. The cap is firmly packed with moist, sifted sand to the level of the base. It is then dipped in melted paraffin to form a protective film that prevents the sand from falling out when the lemon is handled. A number of small perforations are made in the paraffin film so that, when placed on a moist surface, the sand can absorb water and thus keep the lemon turgid. Infested lemons with the cap attached are shown in figure 1.

When a number of lemons have been treated in the manner described, they are placed on a rearing rack such as that illustrated in figure 2. The sand is kept moist by contact of the perforated paraffin film with a wet flannel wick 2 inches in width. This wick is supplied with moisture through contact with a narrow feeder wick that dips into a metal trough attached to one end of the rack and connected to a 1-gallon reservoir of tap or distilled water. When the rearing room is maintained at a temperature of 80° F. and a relative humidity of 65 percent, 1 gallon of water is sufficient for 1 or 2 weeks. Details of the construction of this rack are shown in figure 3.

To infest the fresh lemons, reservoir lemons with frustums and bottle caps attached are placed on flannel wicks lying on the cover of a pan filled with water and are then surrounded by a shade (fig. 4). This pan operates on the same principle as the wooden rack previously described, except that the pan takes the place of the reservoir bottle. To reduce the amount of reflected light in the shade, the white flannel wicks are covered with strips of black cambric cloth and the lower half of the shade is painted black. Detailed plans for the construction of the infesting pan are shown in figure 5. This pan can also be used as a rearing rack, although, being a more recent development, it has not been used as extensively for this purpose. It also requires more sheet metal and is more difficult to construct.

A test to determine the most satisfactory technique for rearing scales by this method indicated that the best results were obtained when the stems were pulled out rather than clipped off close to the base of the lemon. The use of distilled water and sterile sand appeared to offer a slight advantage over tap water and untreated sand, respectively, although the difference in the condition of the lemons would not justify the added expense, particularly with regard to the use of distilled water.

A comparison was made between this method and the bottle method, and for a period of 60 days both gave satisfactory results. For longer periods the lemons can be kept in better condition by the bottle method. The bases of the lemons kept in the sand often turn dark and an occasional one rots before the experiment with the scales is completed. When care is taken in selecting green, turgid lemons from the field this loss can be kept to a minimum.

After the scales have reached the desired stage for parasitization by the particular species of parasite being tested, the lemons are placed in the carrying board shown in figure 6 and are taken to the insectary. These boards have proved useful in keeping the lemons from becoming injured while being transported by car from one location to another.

To parasitize the scales, the infested lemons are placed on a wooden rack similar to the rearing rack previously described. Ground-glass rings, with the hole just large enough to accommodate the base of the metal cap, are placed on the flannel strips, and through this hole the perforated film of the cap makes contact with the moist wick. A glass cage having a ground base is placed over each lemon, and the junction of the two ground-glass surfaces makes a seal through which even the smallest species of parasites

so far experimented with can not escape. A cage placed over an infested lemon on the rack is shown in figure 7.

To obtain the desired parasitization, the scales are exposed to oviposition by about 10 female parasites for a period of approximately 4 days. The lemons are then removed and again placed on the rearing rack until the parasites have reached the desired stage for insecticidal tests. After the treatments have been applied, the lemons are again returned to the rearing rack and held for approximately 3 weeks, at which time the mortality counts of scale and parasite are made.

Laboratory and field tests have been conducted to determine the comparative effect of various insecticidal treatments on the California red scale and its parasite Comperiella bifasciata. In the laboratory tests, lemons infested with parasitized and unparasitized scales are suspended on a rack mounted on a turntable and are revolved at the rate of 20 revolutions per minute as the insecticide is applied. The rack is a modification of the one described by Cressman,^{4/} which consists of

^{4/} Cressman, A. W. Effectiveness against the California red scale of cube resins in light-medium and heavy spray oils. Jour. Agr. Research 66: 413-419.

a laboratory ring stand to which are soldered circular wire loops in which the lemons rest. A slight modification was necessary to accommodate the metal cap attached to the base of the lemon. A three-pronged clip of spring metal is attached to the wire loop (fig. 8). The rim of the cap is placed under two of the prongs and is then forced under the third prong, which serves as a catch.

To determine the effect of field applications of various insecticides on parasite and host, the infested lemons are suspended in the foliage of a tree. The metal cap shown in figure 1 provides a convenient place from which to suspend the lemon without causing any injury to either the fruit or the scales. The lemon is attached to a twig by means of a small binder clip with one of the handles replaced by a modified handle, the extended arms of which engage in holes in the metal cap, and the lemon is suspended as shown in figure 9.

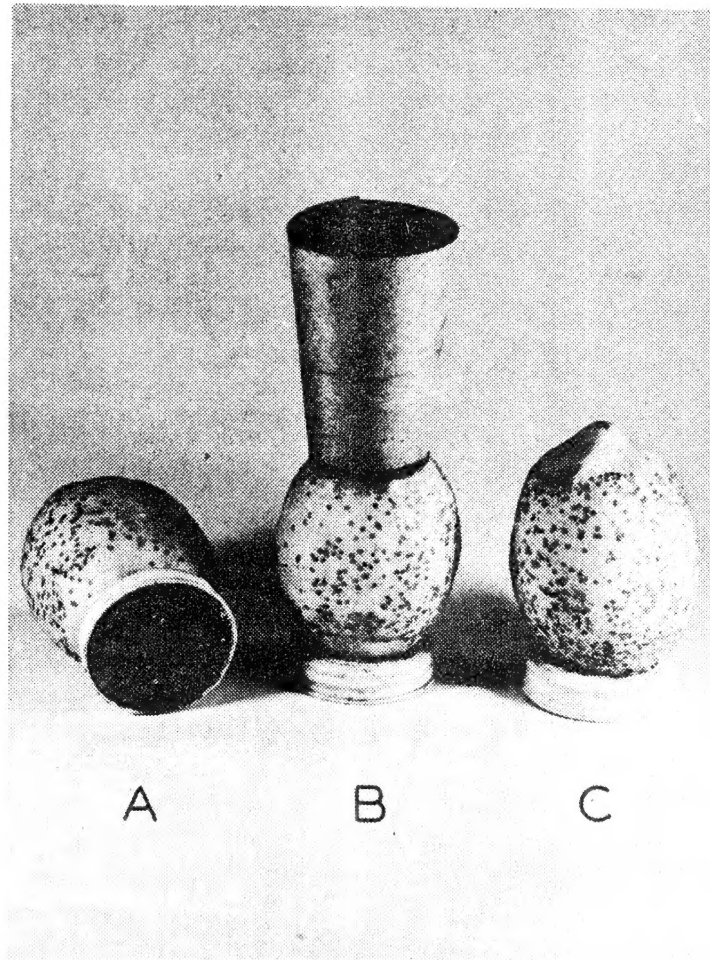


Figure 1.--Infested lemons with metal cap attached to stem end; A, Cap filled with moist sand and covered with a thin, perforated film of paraffin wax; B, reservoir lemon with paper frustum fastened to stylar end; C, reservoir lemon with frustum removed, showing coating of paraffin that prevents crawlers from settling.

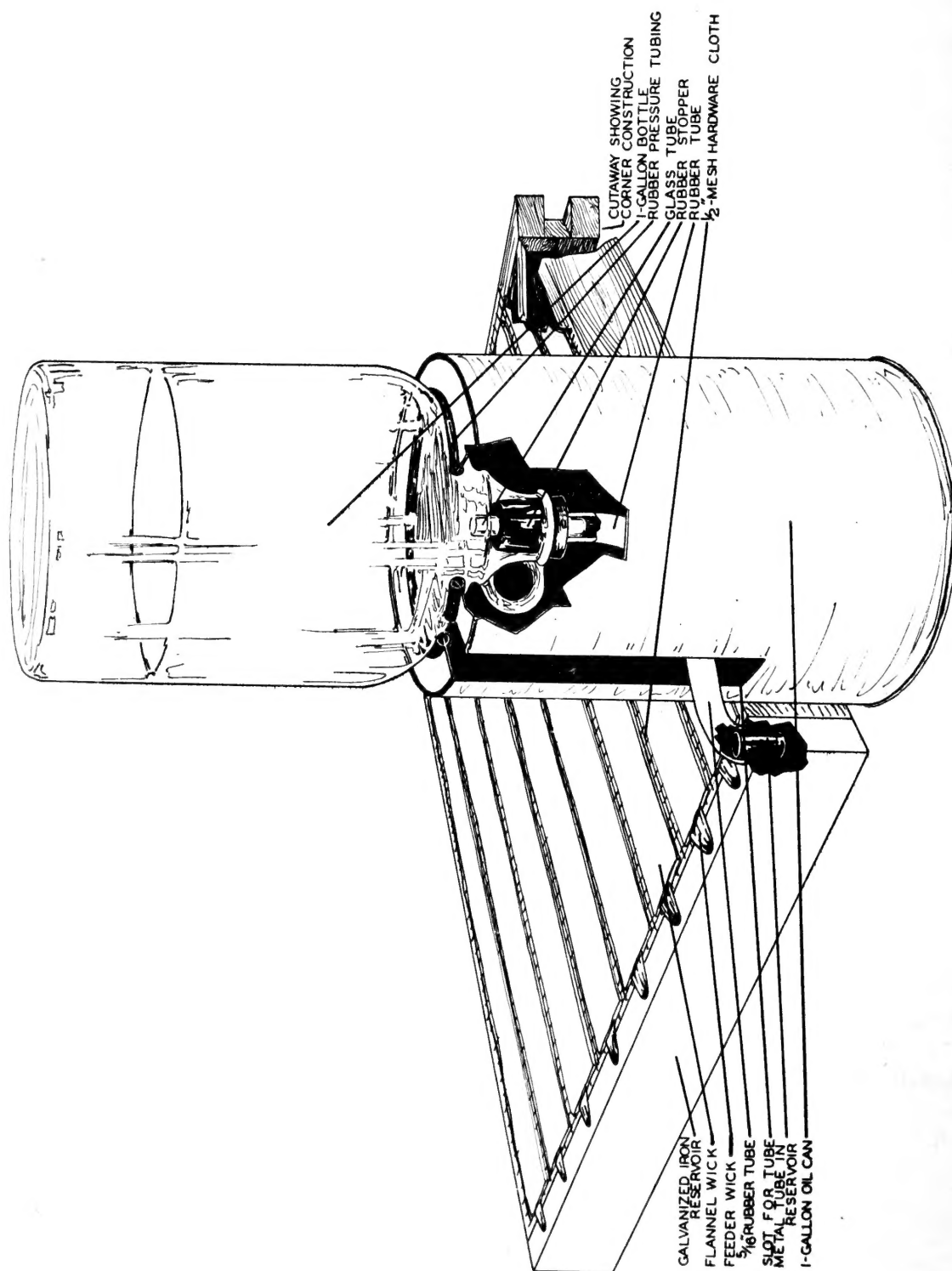


Figure 2.--Pearling rack for keeping lemons turgid while scales are growing. The lemons are placed on flannel wicks kept moist by narrow feeder wicks that dip into the reservoir trough.

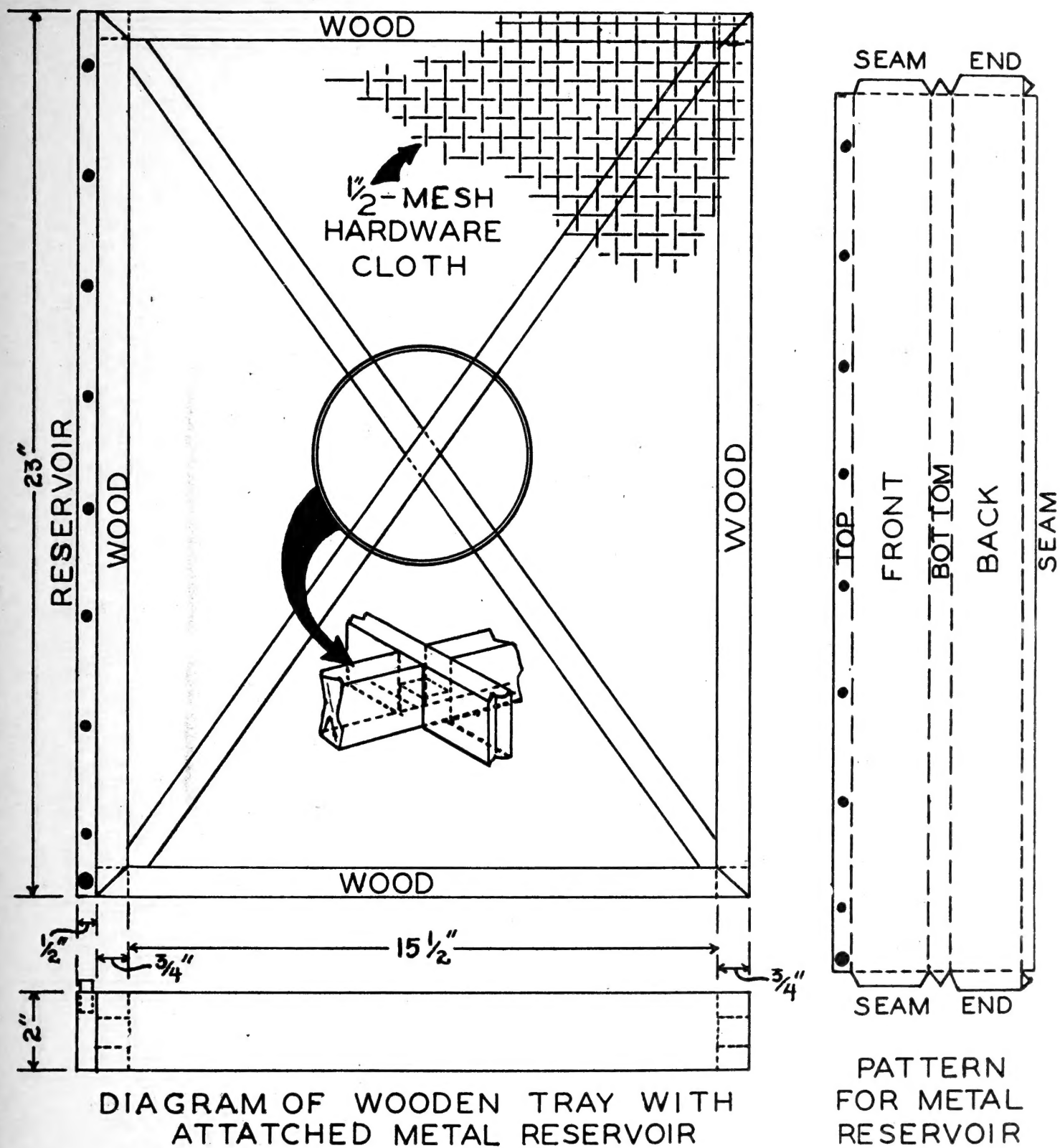


Figure 3.--Details of construction of the rearing rack.

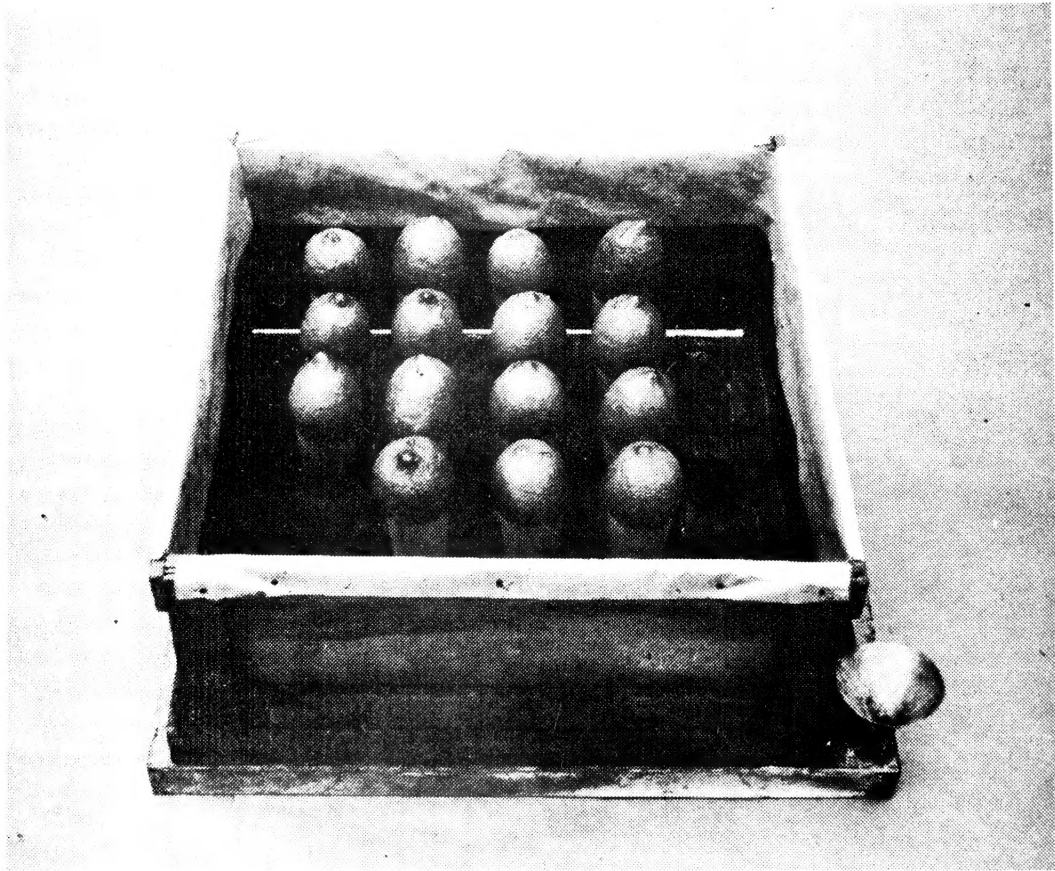


Figure 4.--Infesting pan for holding reservoir lemons while green, fresh lemons are being infested with crawlers. The pan operates on the same principle as the rearing rack, except that no reservoir bottle is used.

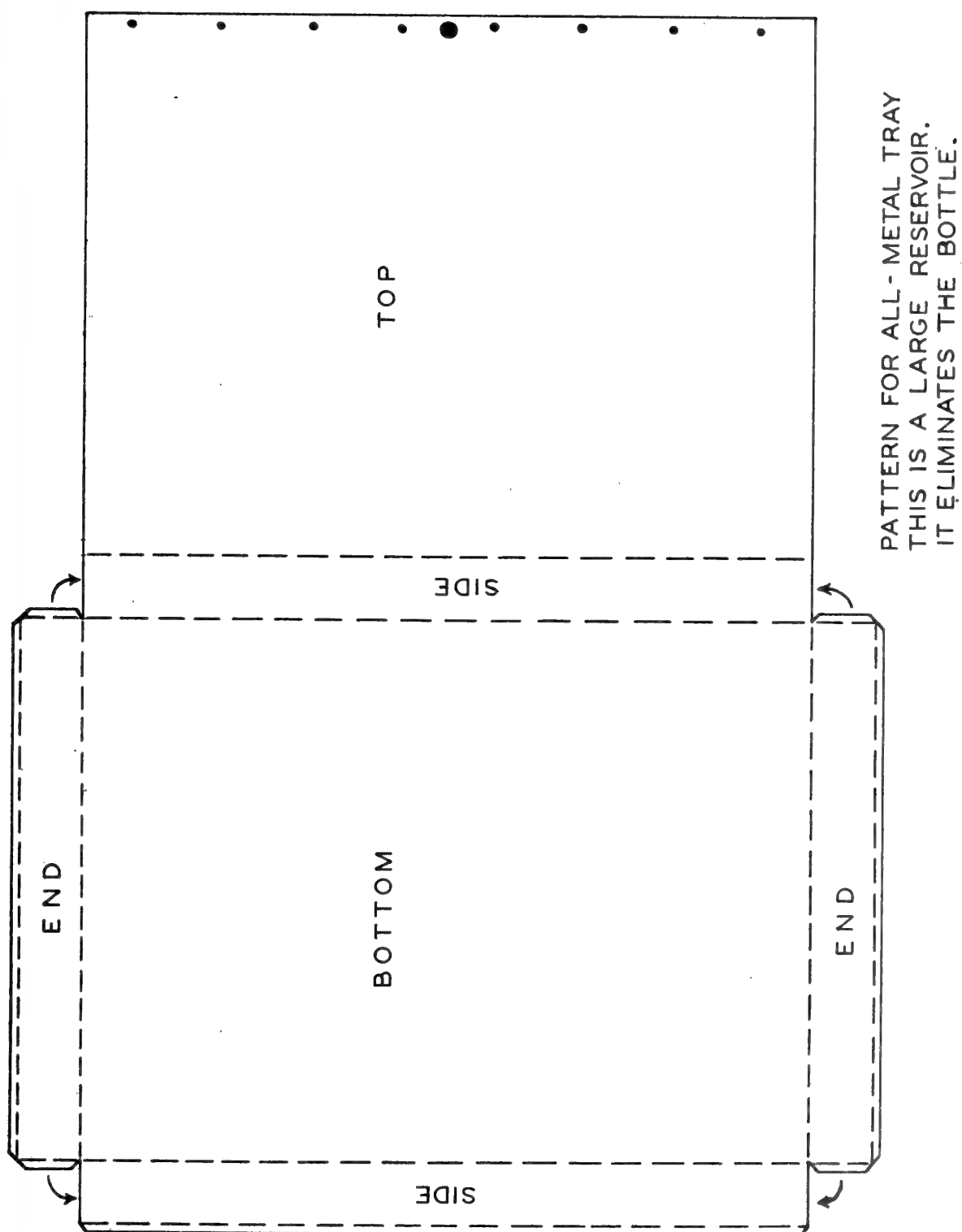


Figure 5.--Details of construction of the infesting pan.

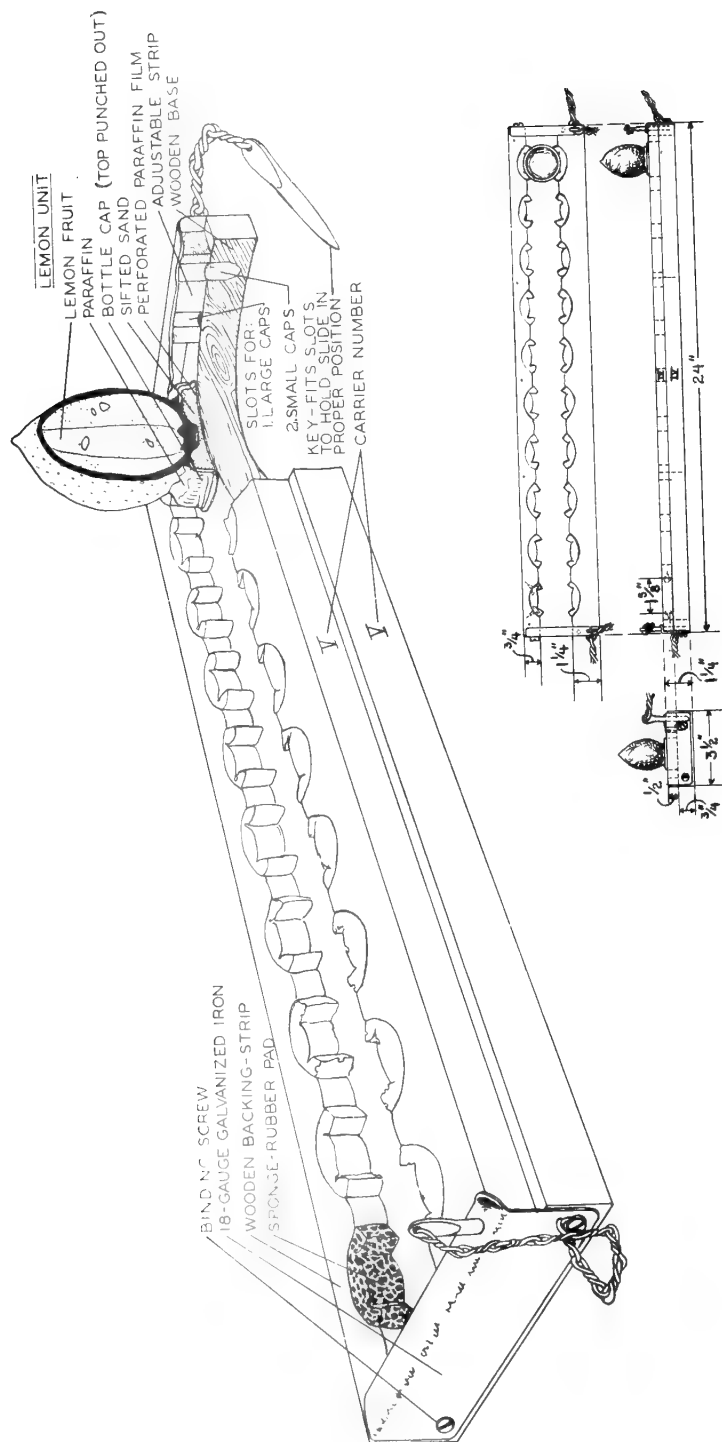


Figure 6.--Carrying board for holding infested lemons while being transported by car from one location to another.

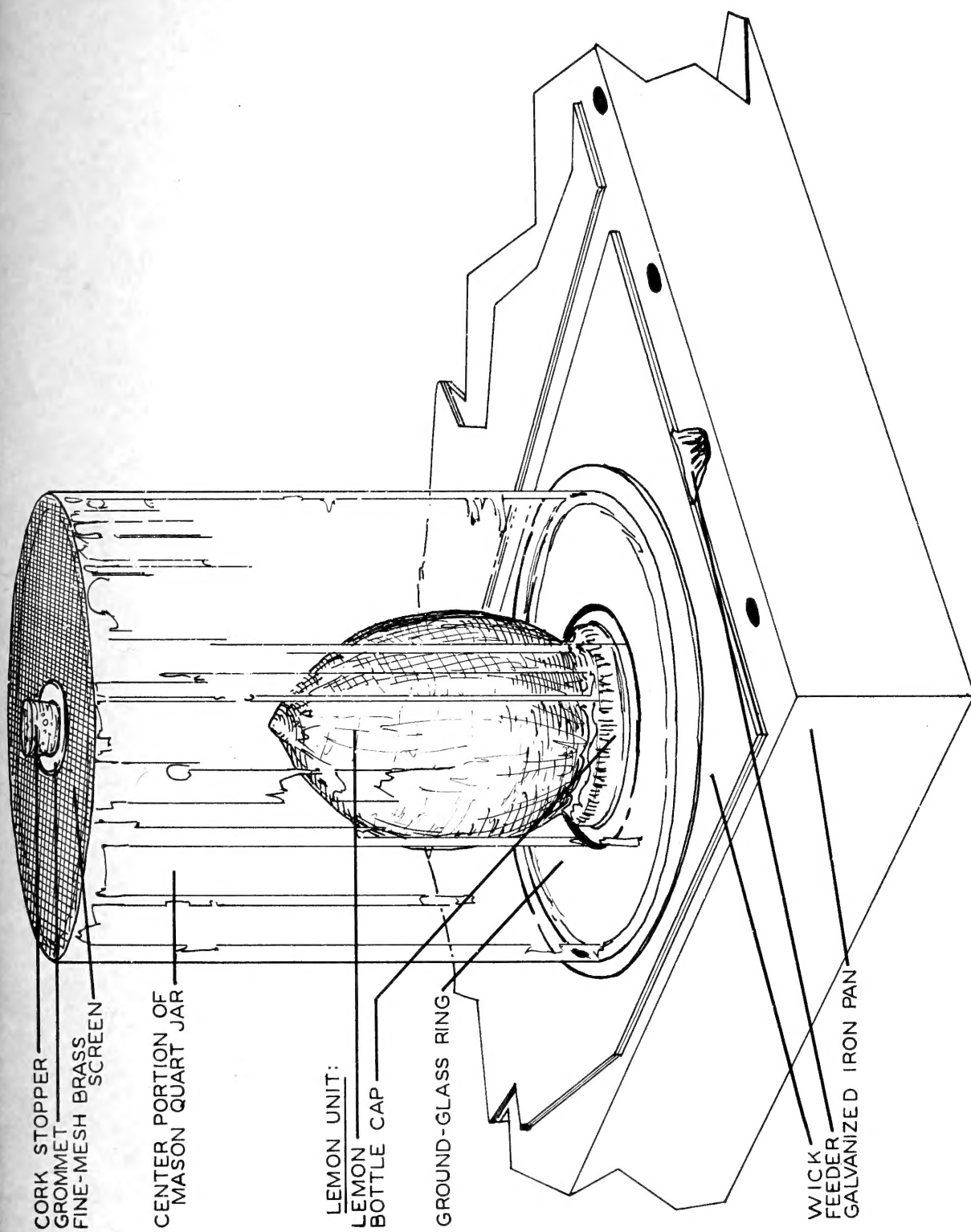


Figure 7.--Method of parasitizing scales. The metal cap attached to the infested lemon is placed in the hole of the ground-glass ring so that the paraffin film touches a flannel wick.

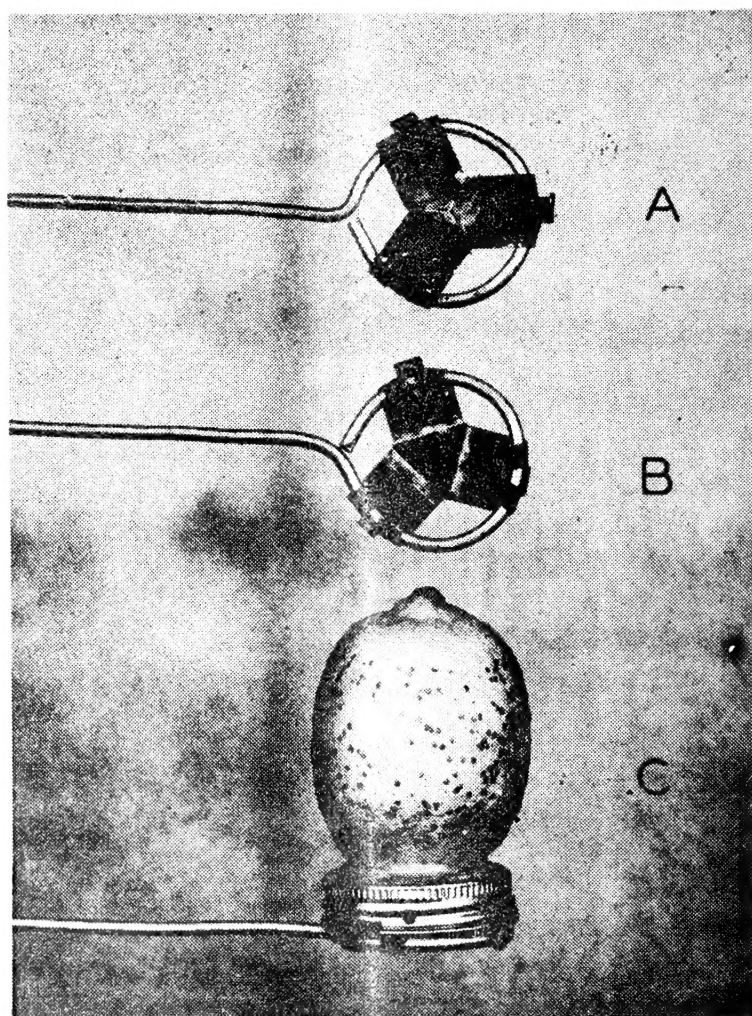


Figure 8.--Spring-metal clip for attaching a lemon to a spraying rack: A, Top view; B, bottom view; C, side view showing lemon mounted in position for being sprayed.

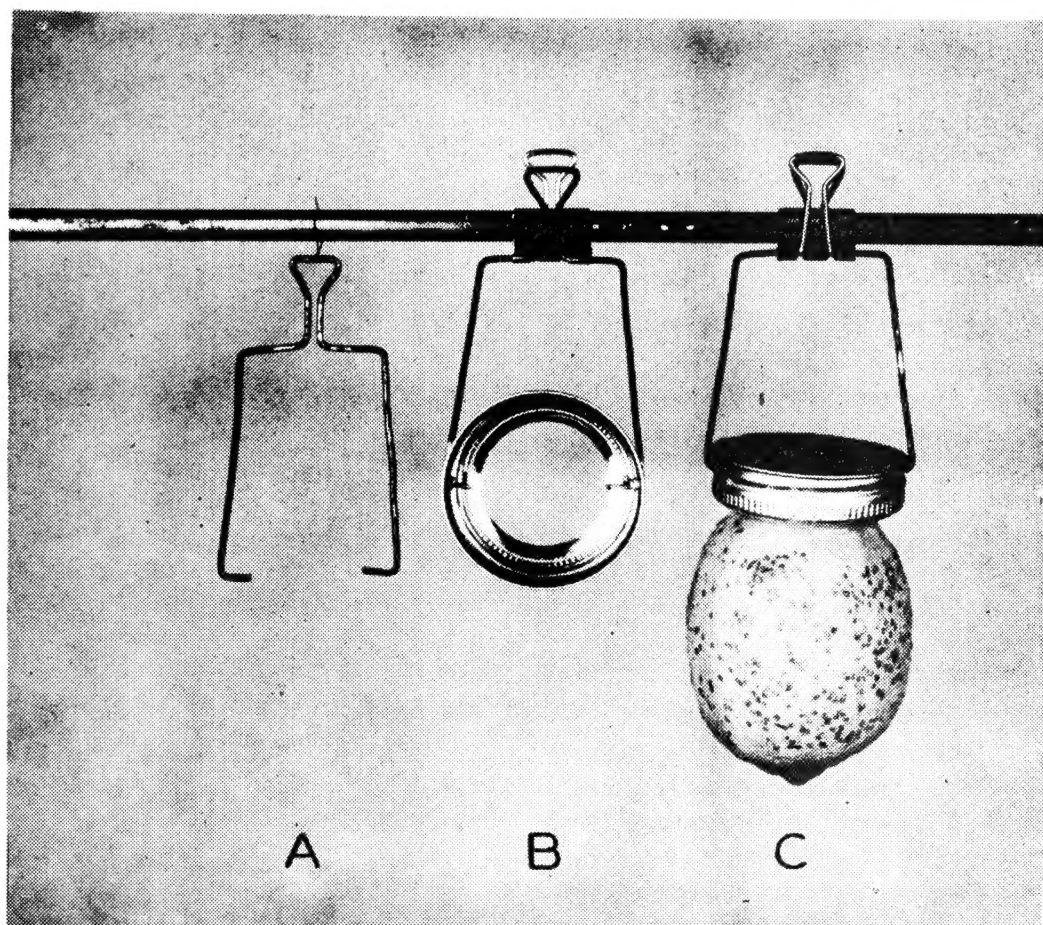


Figure 9.--Clip for attaching a lemon to a twig: A, Modified handle; B, method of attaching arms of clip to metal cap; C, lemon suspended in position for spraying.

